OUM- A 180 nm Non-Volatile Memory Cell Element Technology For Stand Alone and Embedded Applications

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Agenda

- Introduction
- OUM Technology Concept
- Cell Element Characteristics
- Scaling and Cost Issues
- Conclusions

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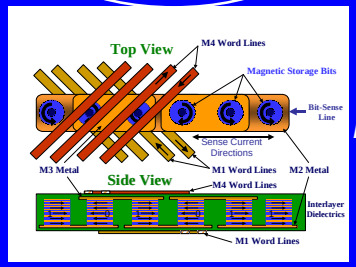
Introduction

- Industry is searching for an ideal non volatile memory
  - Non Volatile
  - Fast write, fast read
  - Low cost
- Many research and development projects reported
  - Some will bear fruit in the next few years

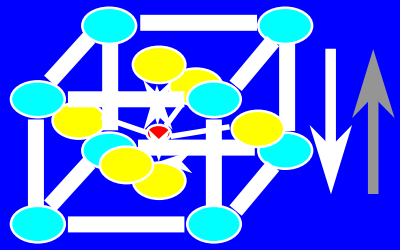
More New Technologies Than Any Time In History

MRAM

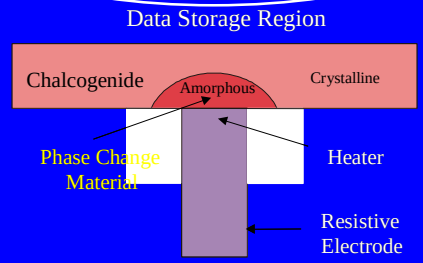


Applied Electric Field Moves Center Atom

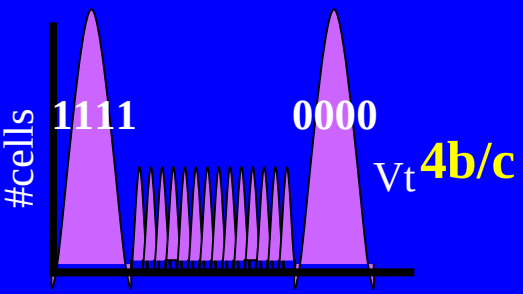
FERAM



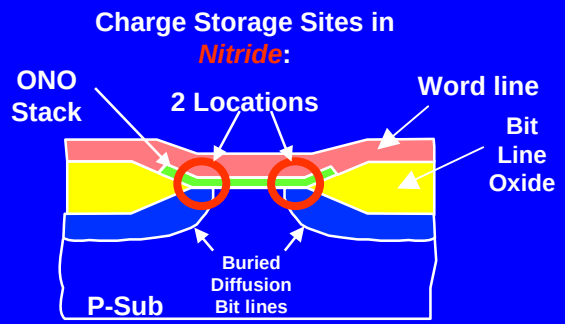
OUM



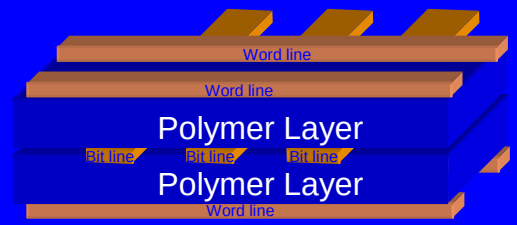
ETOX-4bpc



NROM



Polymer



One or two will become mainstream!

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Chalcogenide Material

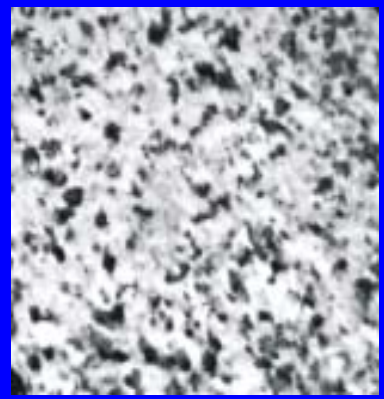
- Chalcogenide is the general class of switching media in CD-RW and DVD-RW
  - In high volume production and low cost
- Laser beam energy is used to control the switching between crystalline and amorphous phases
  - Higher energy -> amorphous
  - Medium energy -> crystalline
- Low energy laser beam to read

Amorphous vs Crystalline Phases

Amorphous Phase

Scale:

0.2 microns



Crystalline Phase

Electron Diffraction Patterns

Short Range Atomic Order

Low Free Electron Density

High Activation Energy

High Resistivity

Long Range Atomic Order

High Free Electron Density

Low Activation Energy

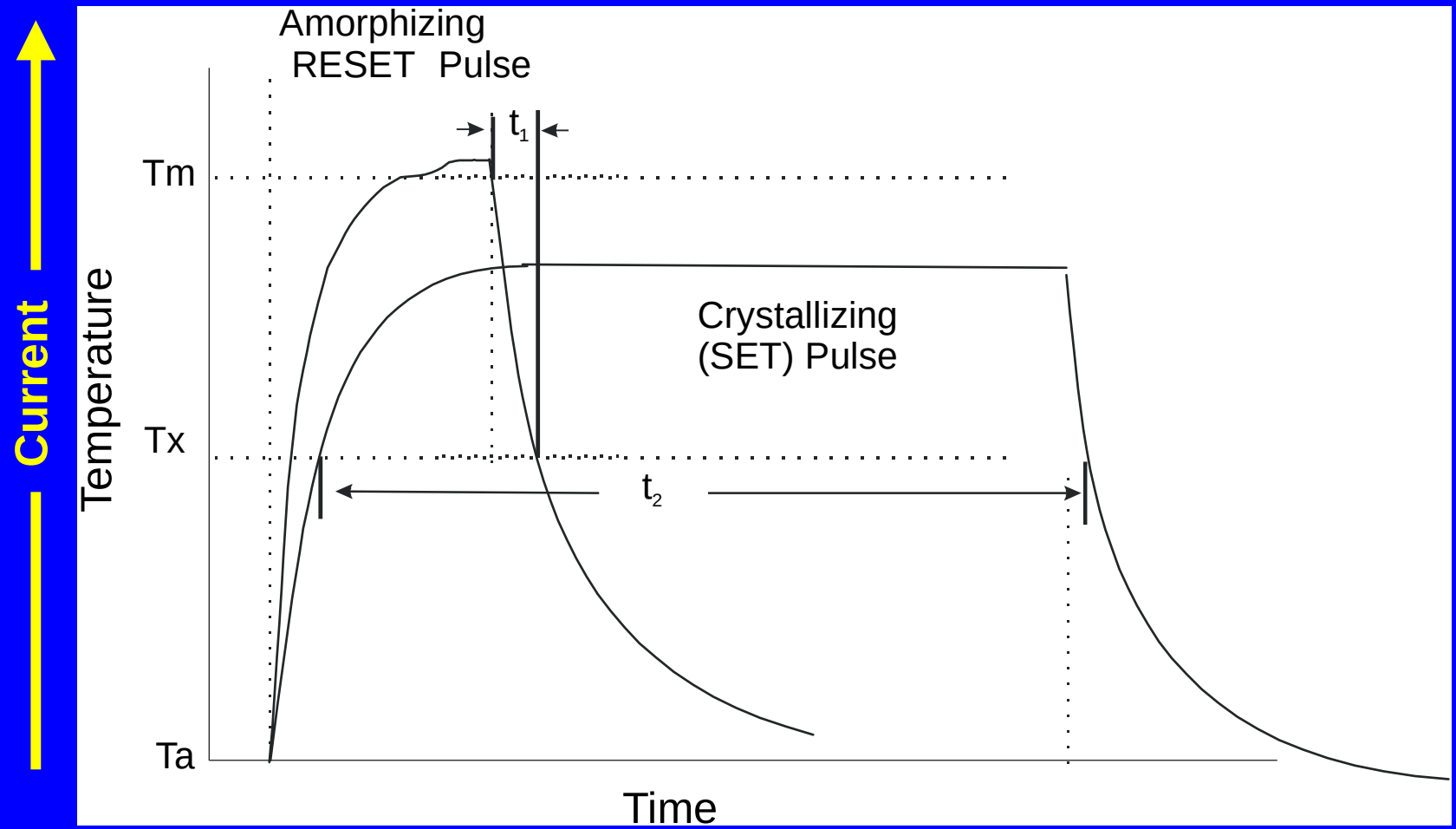
Low Resistivity

Material Characteristics

Ovonics Unified Memory (OUM)

- Instead of using laser beam, electric current is used to heat the material to switch between amorphous and crystalline phases
  - High current, high temperature: amorphous phase, high resistance
  - Medium current, lower temperature: crystalline phase, low resistance
- Low current to sense resistance

Basic Device Operation



OUM in 1970

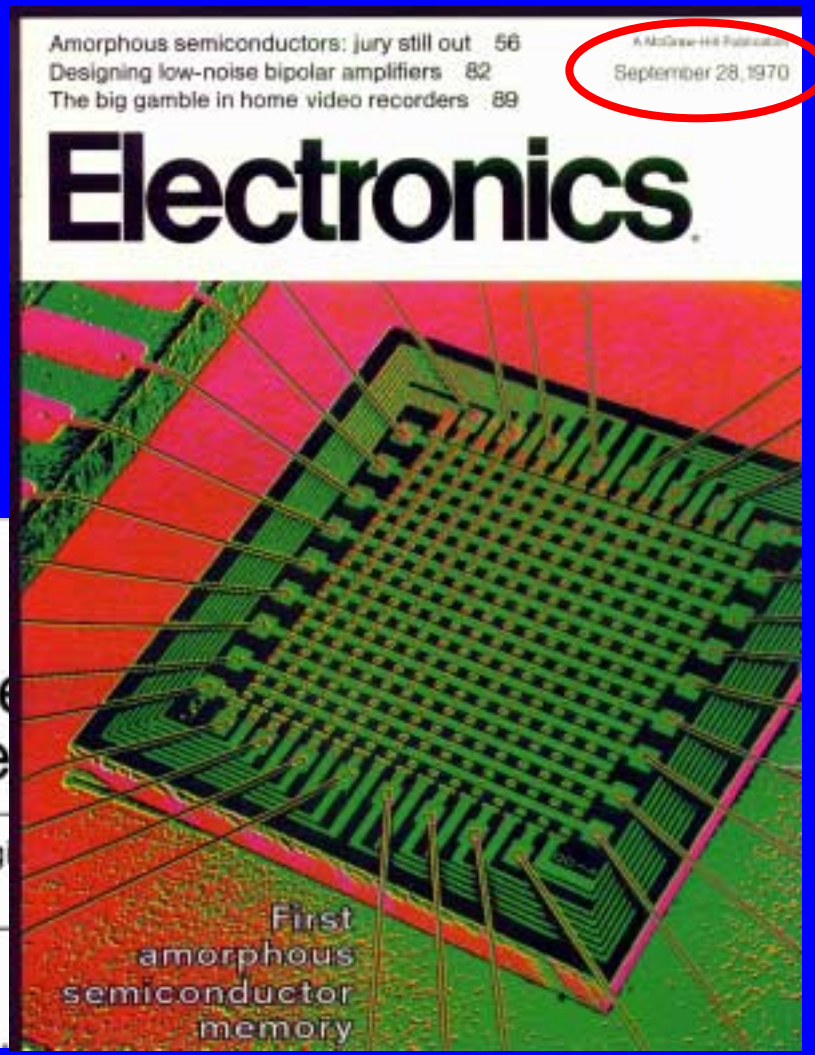
- **Chalcogenide memories have been studied for > 30 years**

Amorphous semiconductors Part I

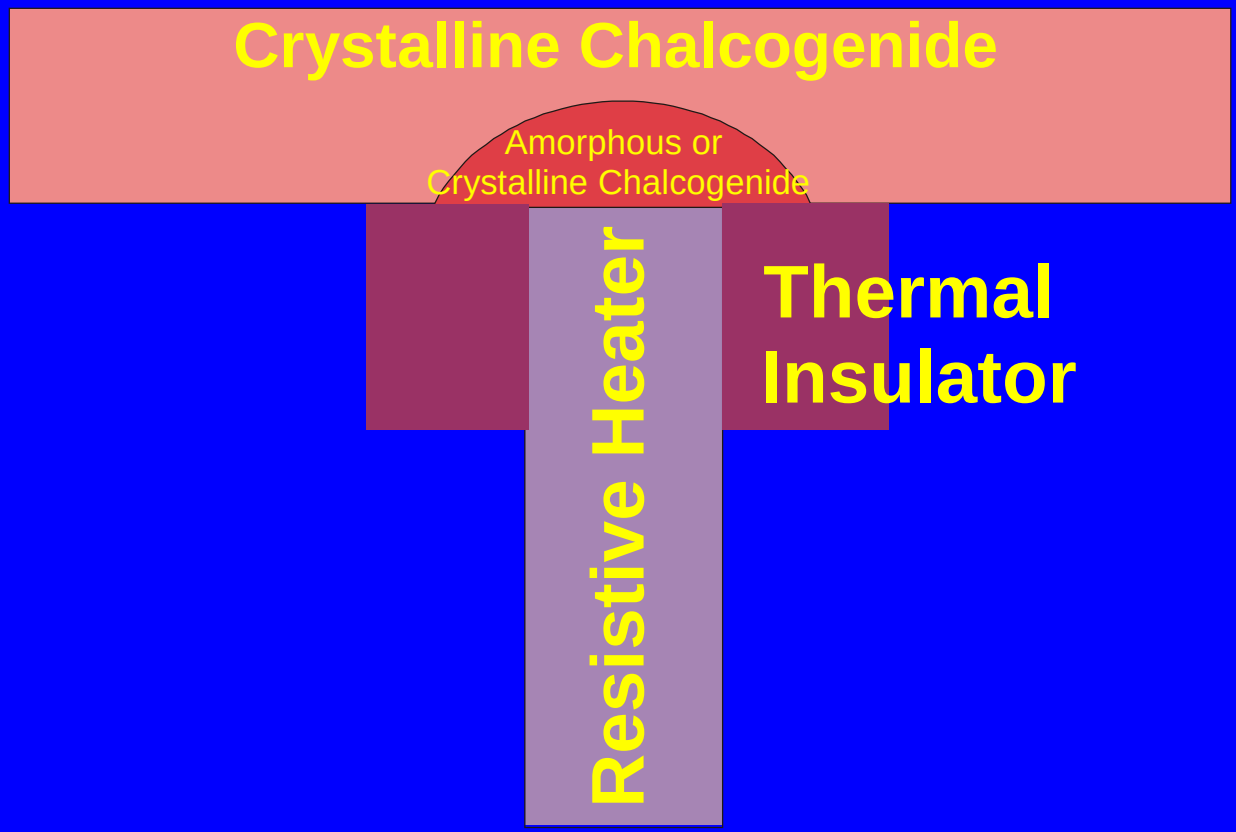
Nonvolatile and reprogramable
the read-mostly memory is he

Integrated arrays combine amorphous and crystalline technologi
new memories could help realize promise of microprograming

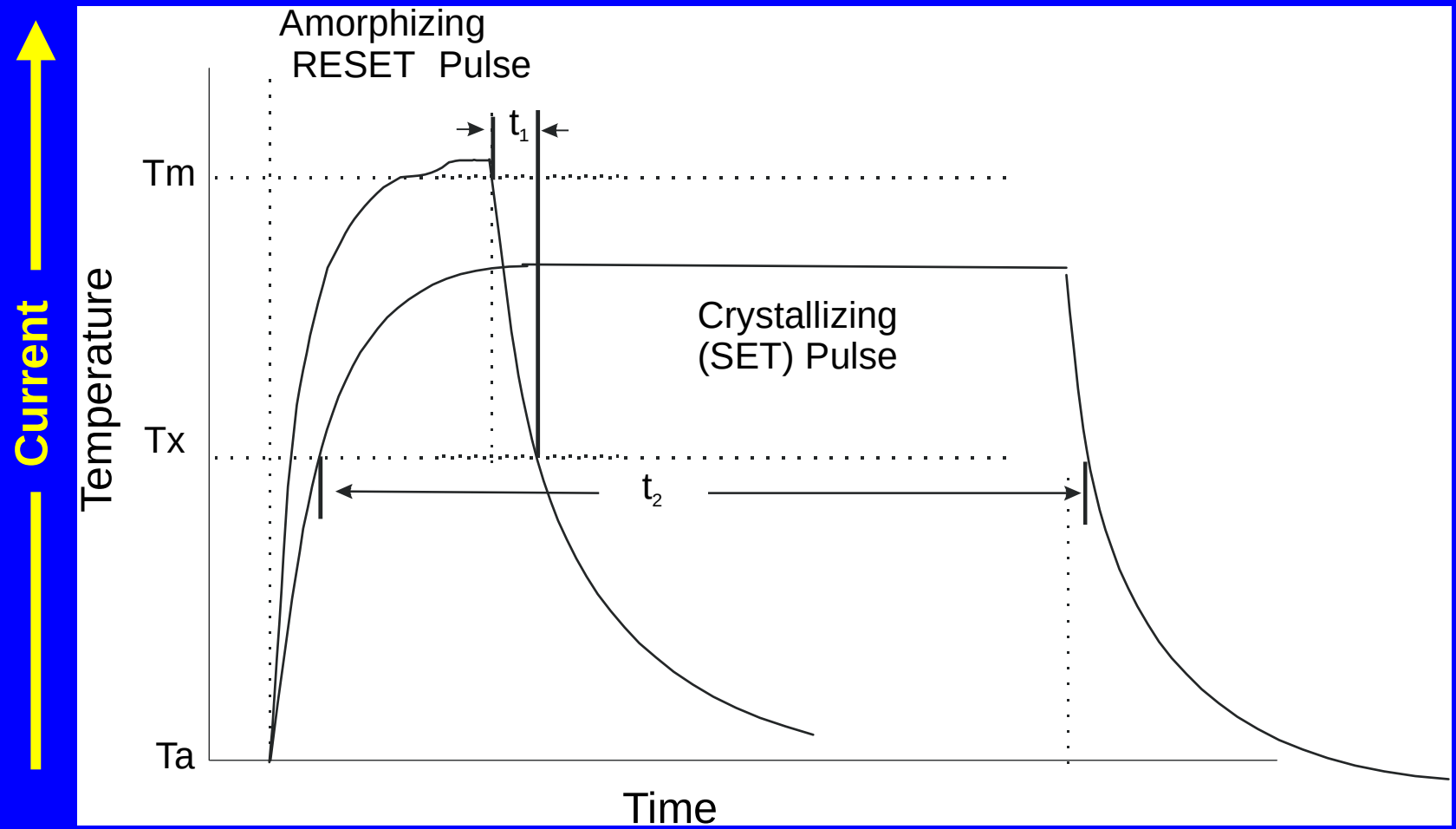
By R. G. Neale and D. L. Nelson, *Energy Conversion Devices, Inc., Troy, Mich.*
Gordon E. Moore, Intel Corp., *Mountain View, Calif.*



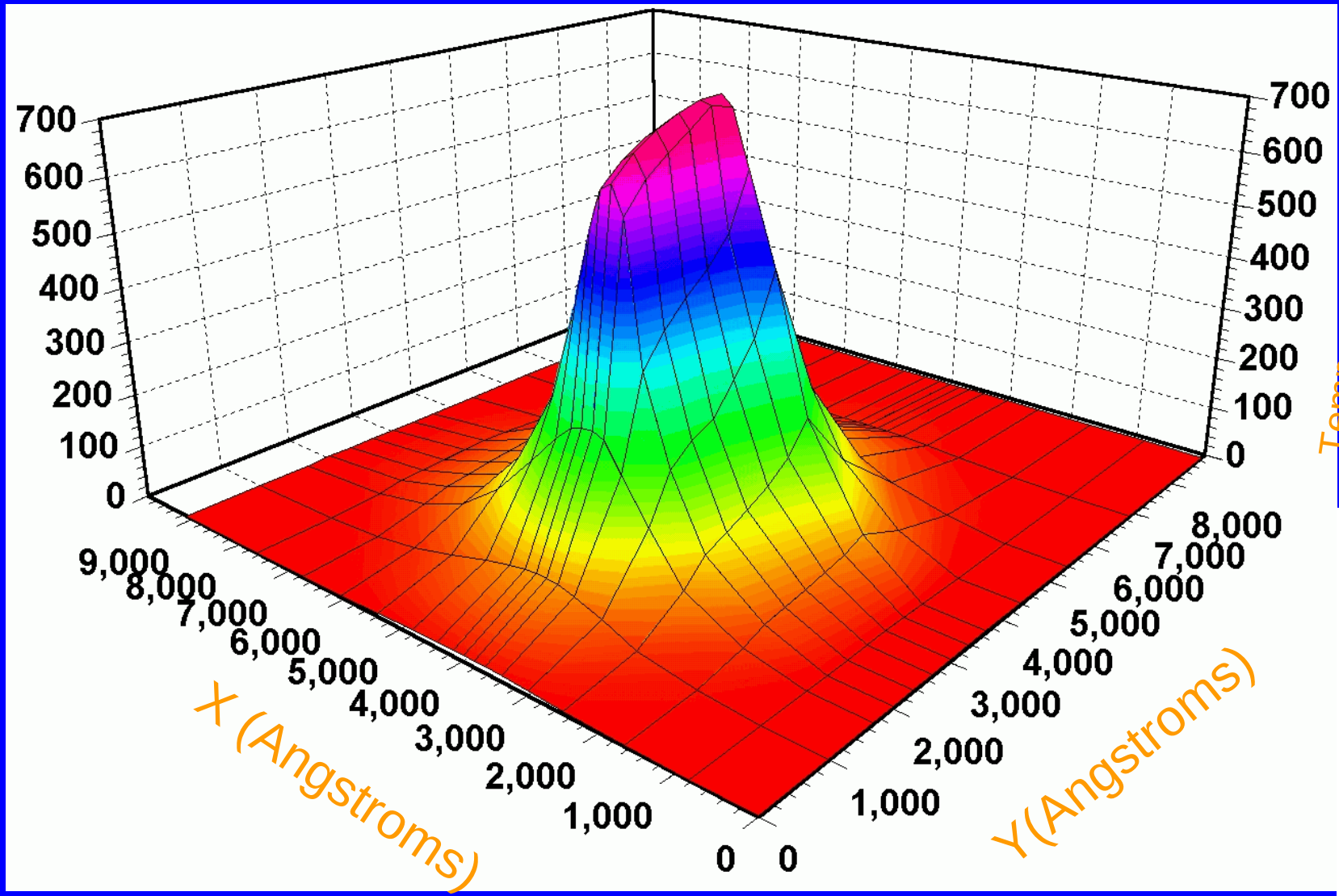
Current Memory Structure



Basic Device Operation



3D Temperature Profile of Heating



Heating of a 500A X 2000A device during a 20ns Reset Pulse

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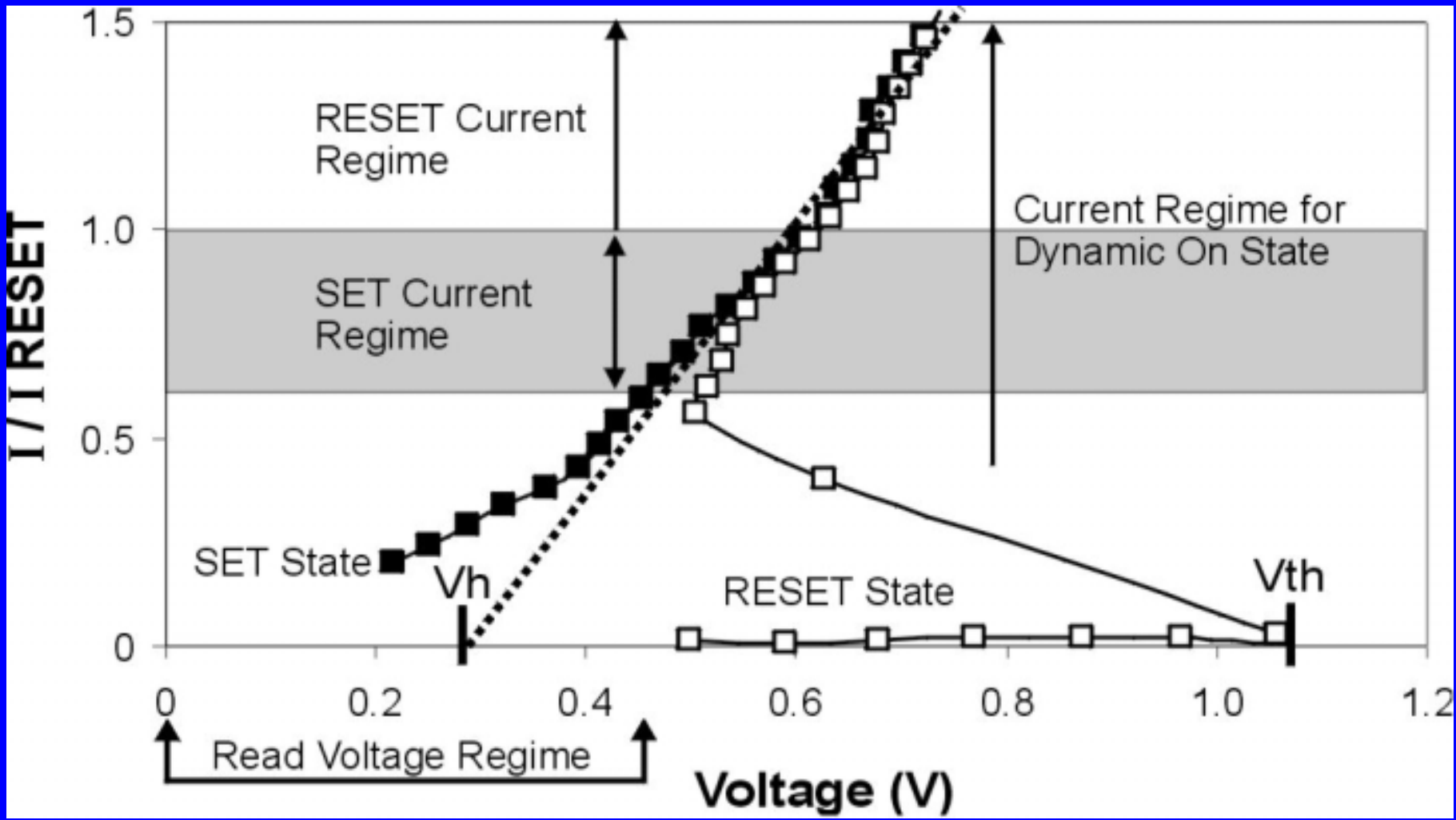
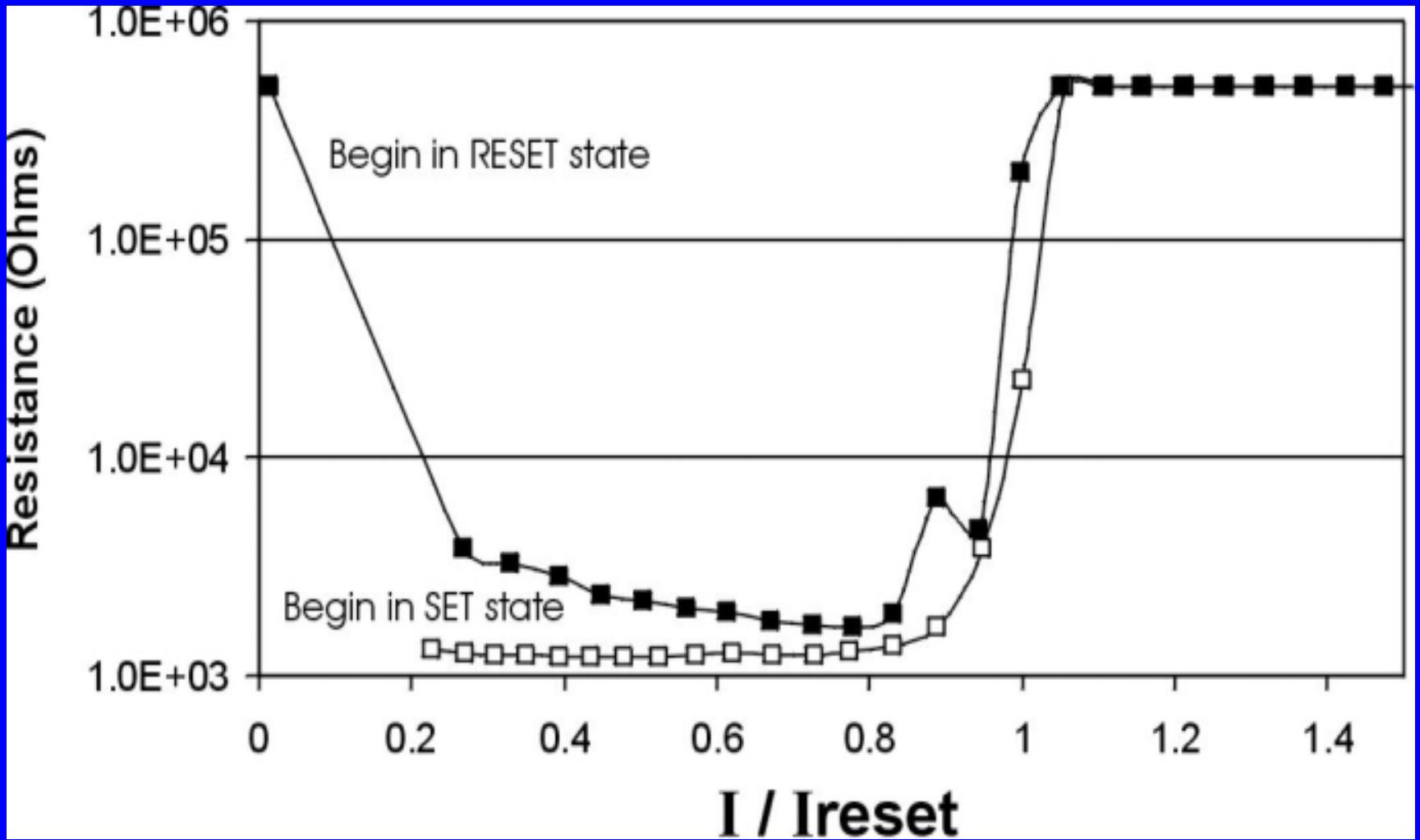
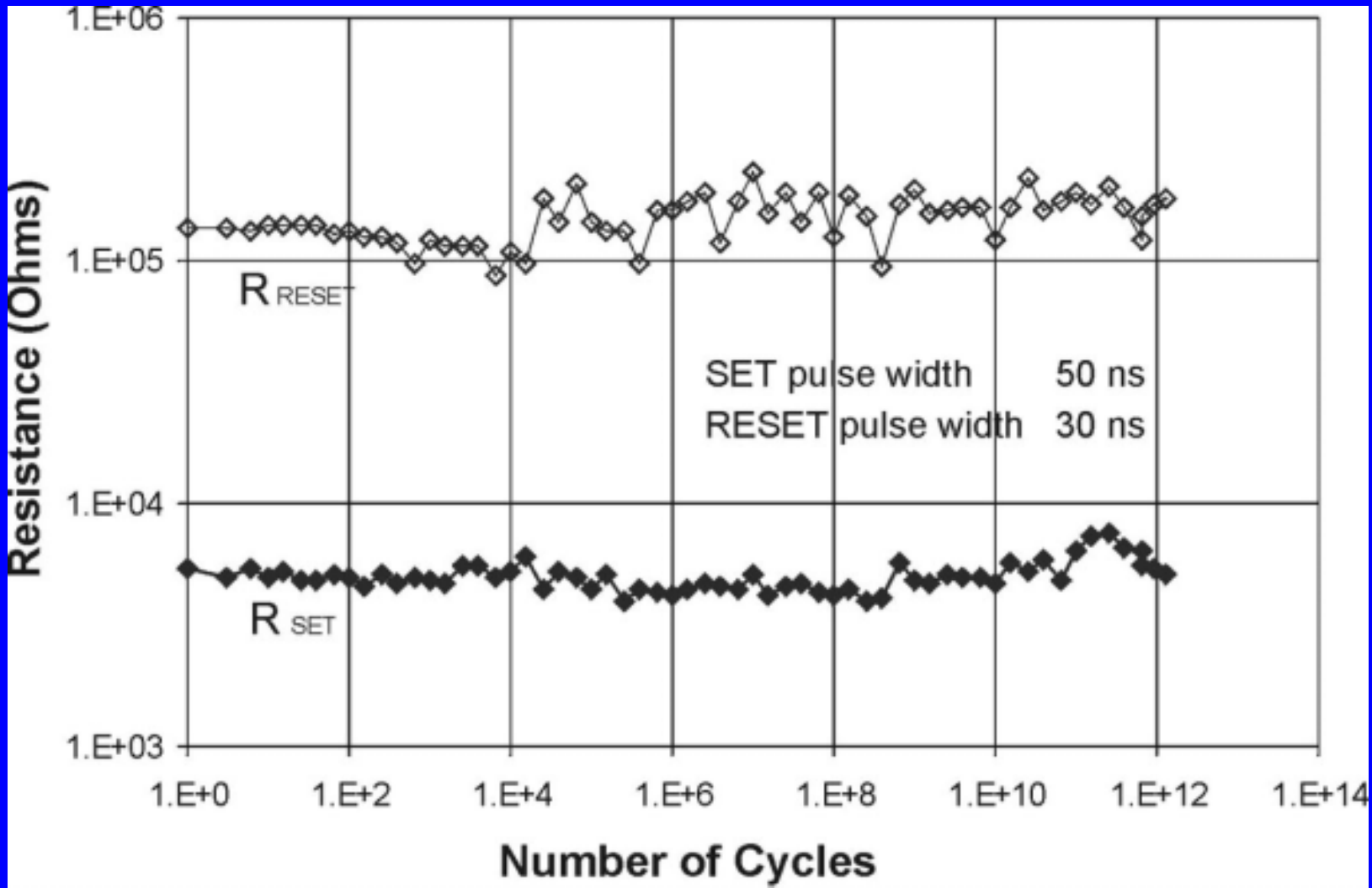
IV Curve of Chalcogenide Element



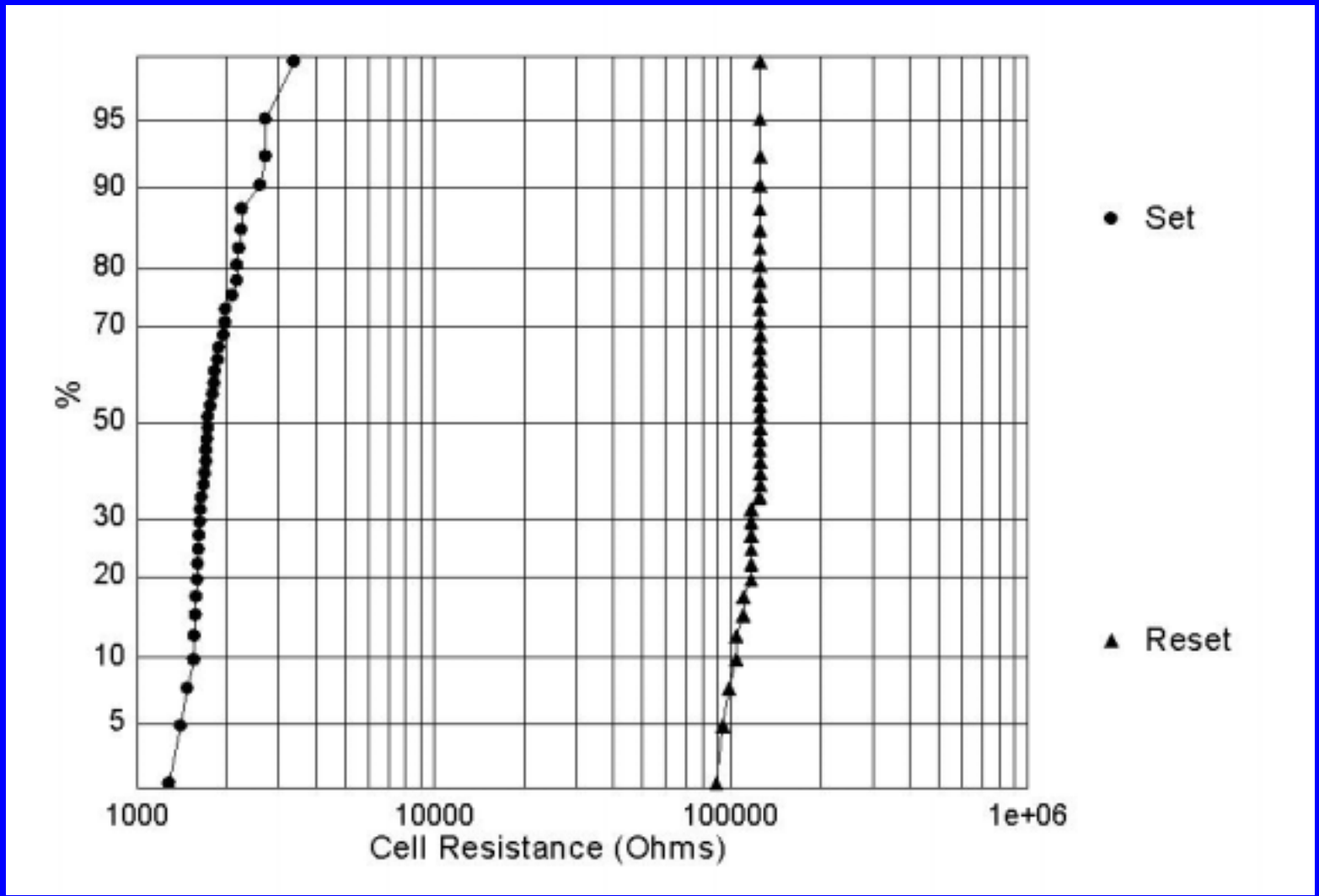
R_{set} and R_{reset} as Function of Cell Current



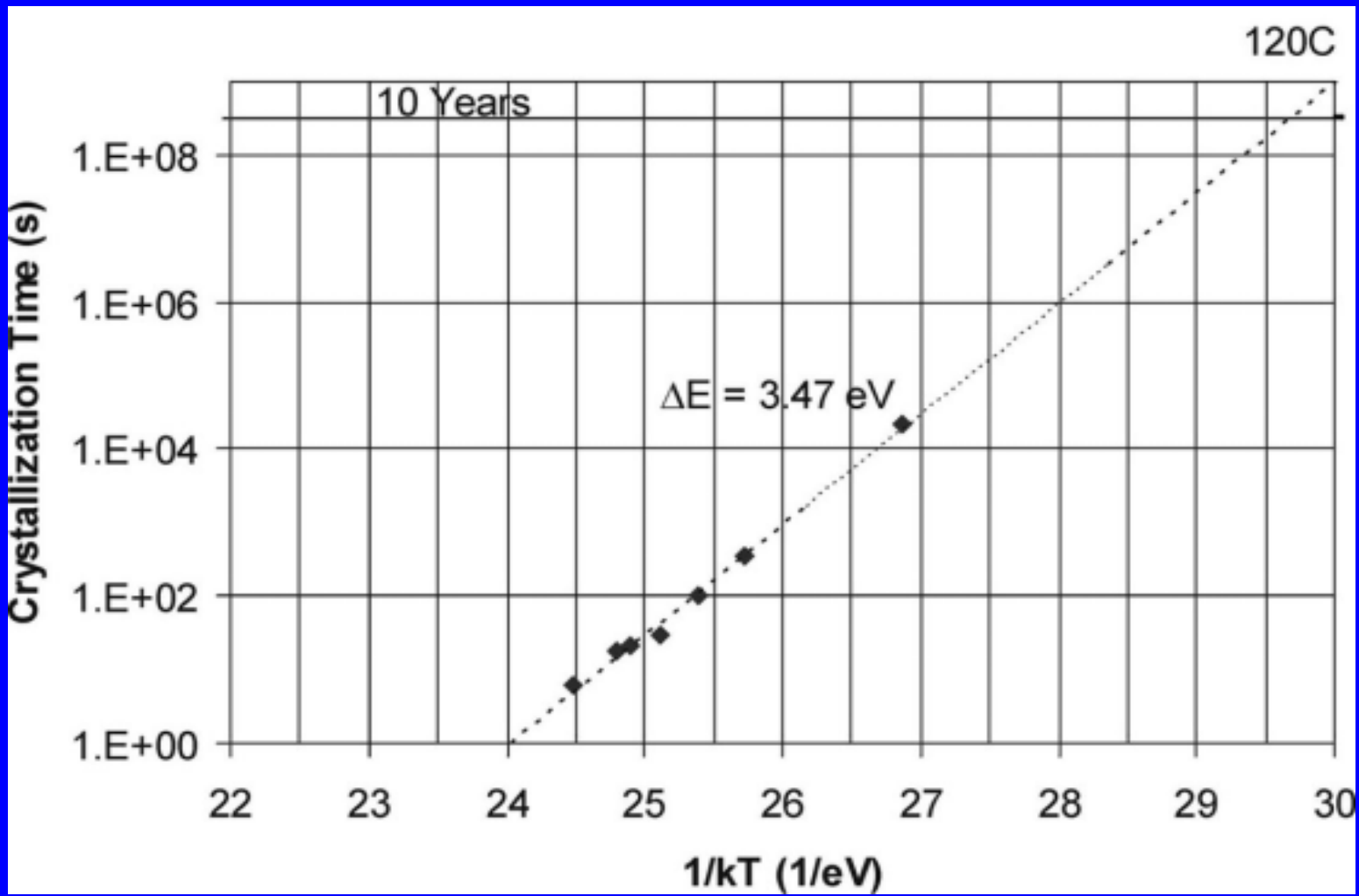
R_{set} and R_{reset} as Function of Cycles



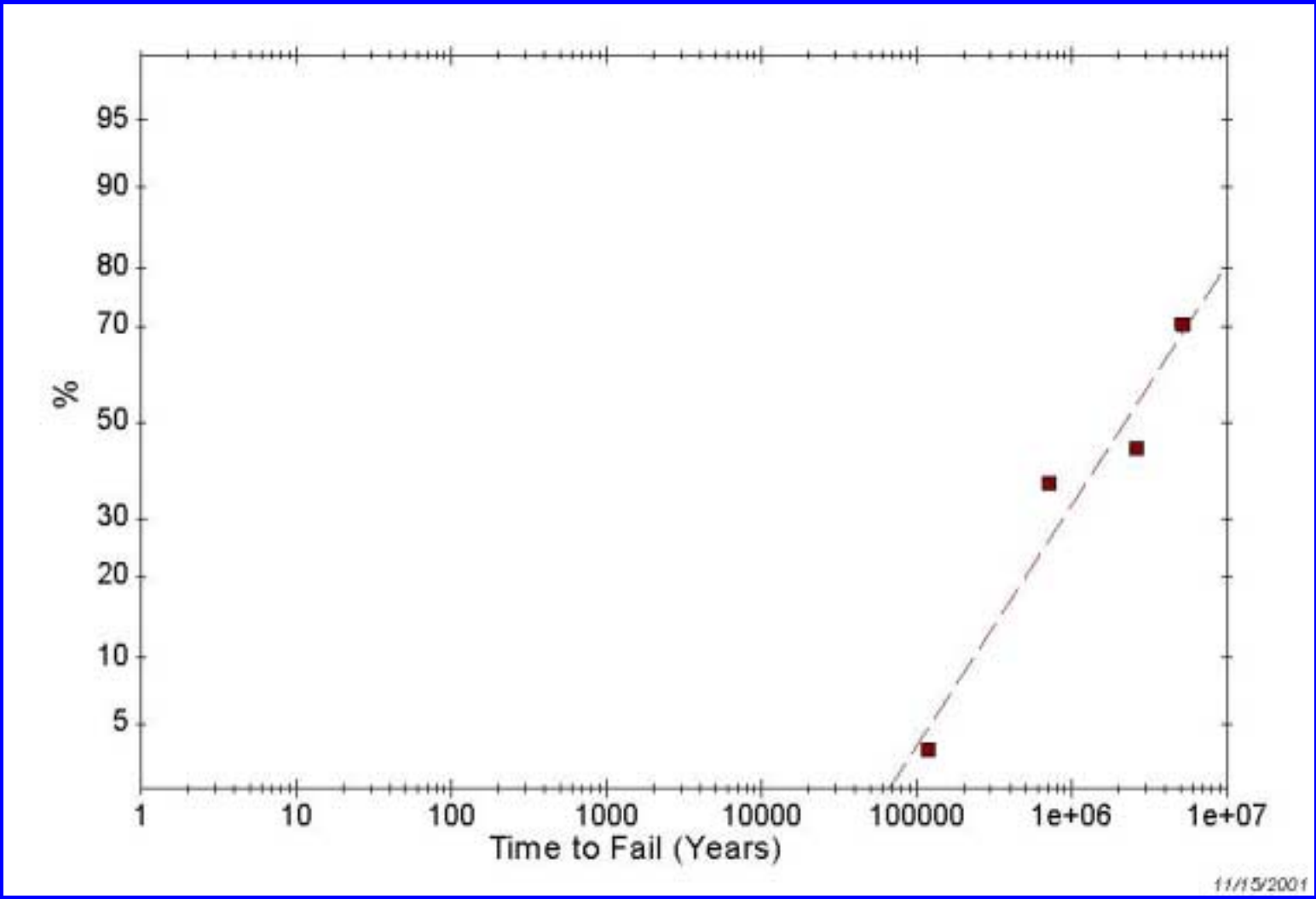
R_{set} and R_{reset} Distribution after 10^7 Cycles



Intrinsic Retention Characteristics



Failure Rate at 70ºC after 10^7 Cycles



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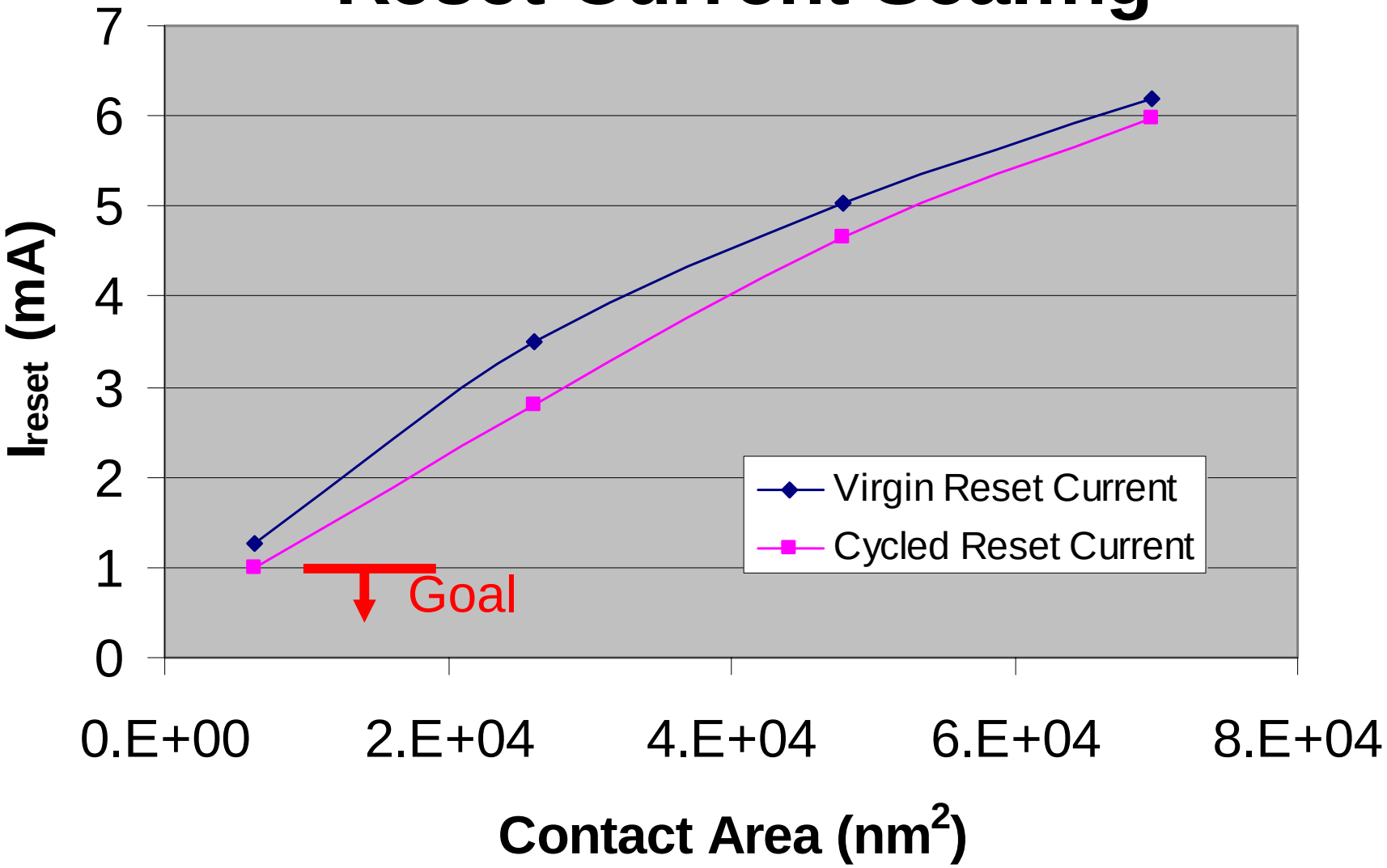
Scaling

- Set and reset currents scale with the contact area; switching observed down to the smallest dimensions
- Thermal proximity is a concern: simulation showed capability down to 65 nm node, new structure and new material will extend to smaller geometries

Reset Current Scaling



Scaling

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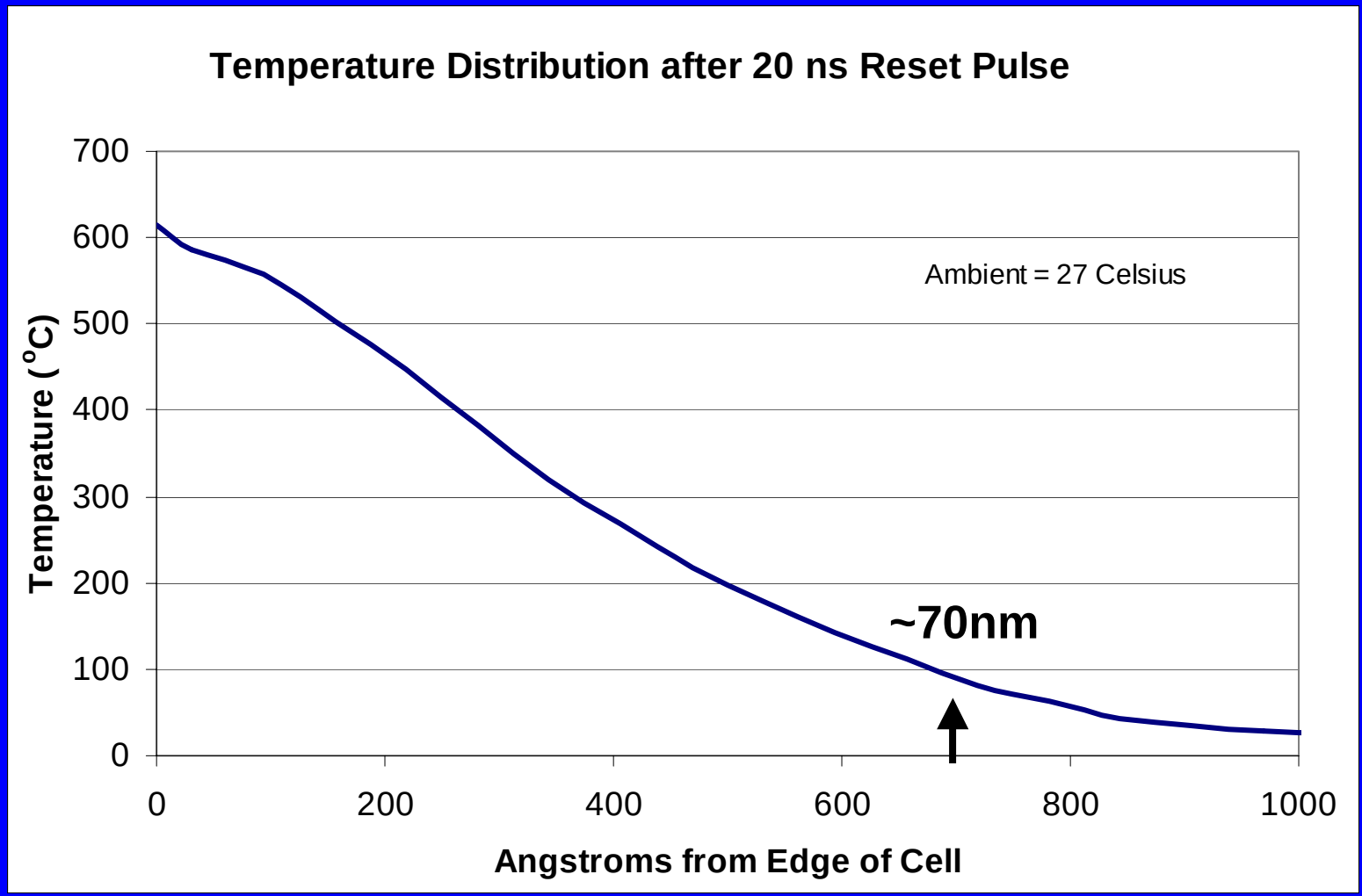
Temperature vs Radial Distance
For a Scaled Device



Cost Adder To Standard Process

- Chalcogenide material compatible with standard silicon processing
- Cell structure added after transistor formation before contact and interconnect
  - Standard metal process temperature has no impact on cell characteristics
- 3V transistor required, standard in most processes
- Minimal incremental process steps “bolt on” to standard process

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Conclusions

- Reproducible electrical switching of Chalcogenide material on a 180 nm scaled device has been demonstrated
- This OUM element can be a new building block in a new class of low cost non volatile memories both for stand alone and for embedded applications

Backup

Pulse width dependence of R_{set} and R_{reset}